Earth Science Technology Conference 2003

A High Performance Image Data Compression Technique for Space Applications

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Acknowledgement: CAMBR/U Idaho team and Wai Fong (GSFC)

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CONTENT

- Requirement for Space Applications
- Compression Scheme
- CCSDS WG Selection
- Performance
- Technology Status

HIGH PERFORMANCE DATA COMPRESSION
requirement for space applications

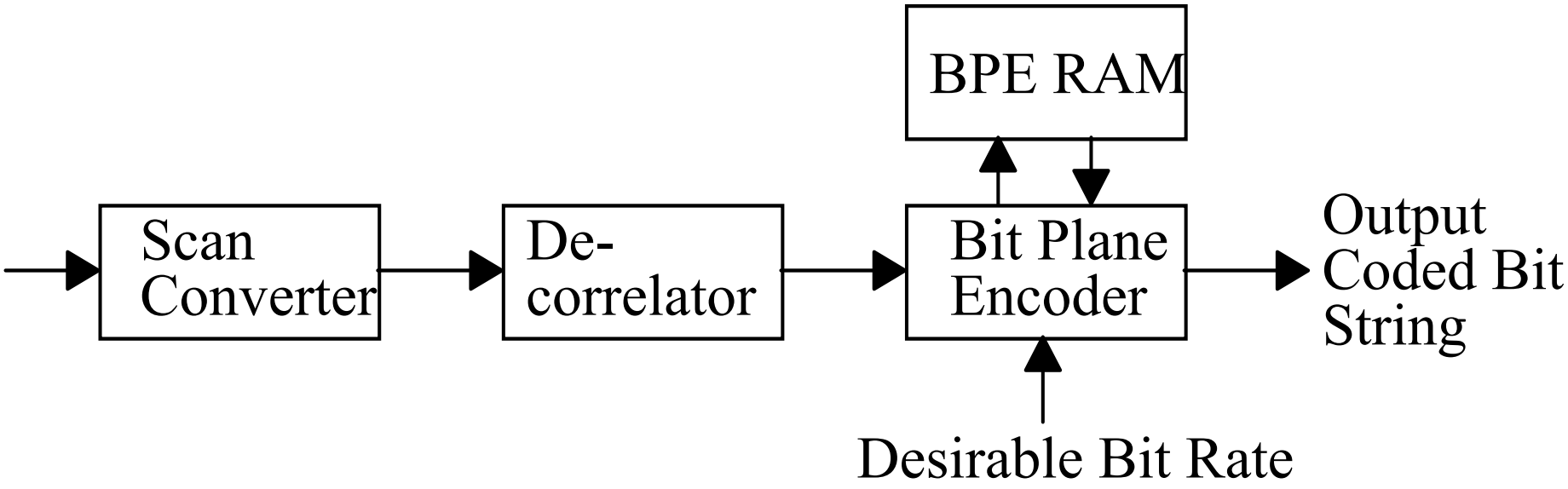
Requirements established by Consultative Committee for Space Data Systems (CCSDS) Compression Working Group in 1998:

- Offer "Royalty free" algorithm
- Process both non-frame based (push broom) and frame based input source data.
- Offer adjustable data rate.
- Work with large source quantization ranges up to 16 bit-per-pixel
- Offer real-time processing >= 20 Msamples/sec,
  at <= 1 watt/Msamples/sec.

The power consumption includes all buffering and support electronics.

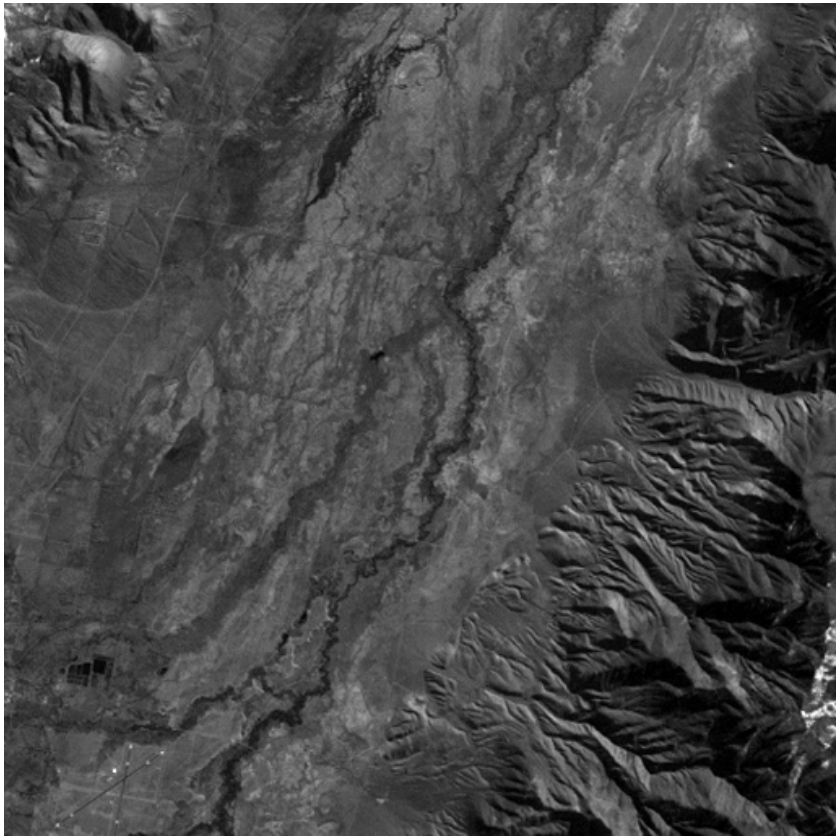
- Require minimum ground interaction during operation.
- Allow packetization for error containment.
- Allow progressive transmission/Decoding (optional)

GSFC/NASA TECHNIQUE

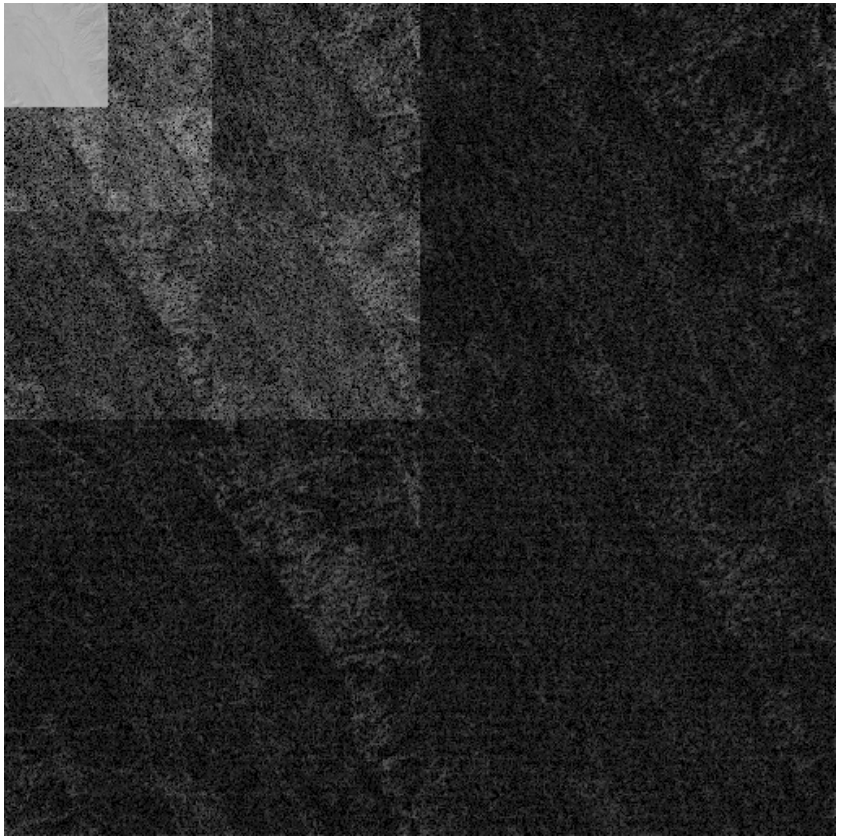


De-correlator: Discrete Cosine Transform, Lapped Transform, Wavelet Transform

Transform Domain

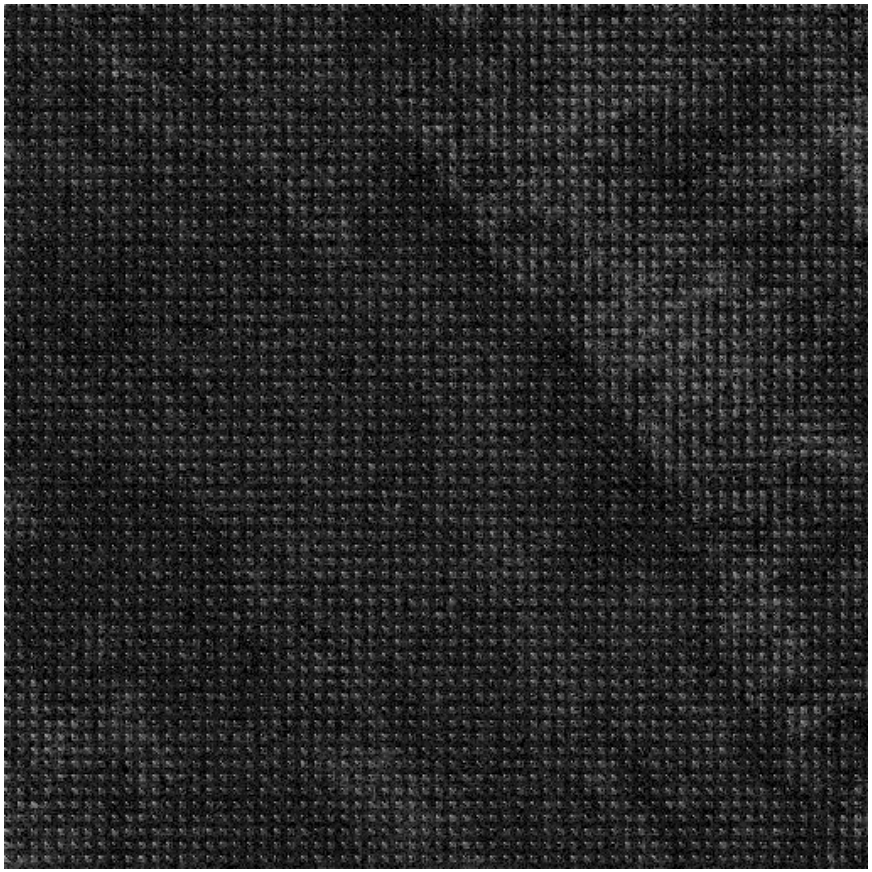


Original

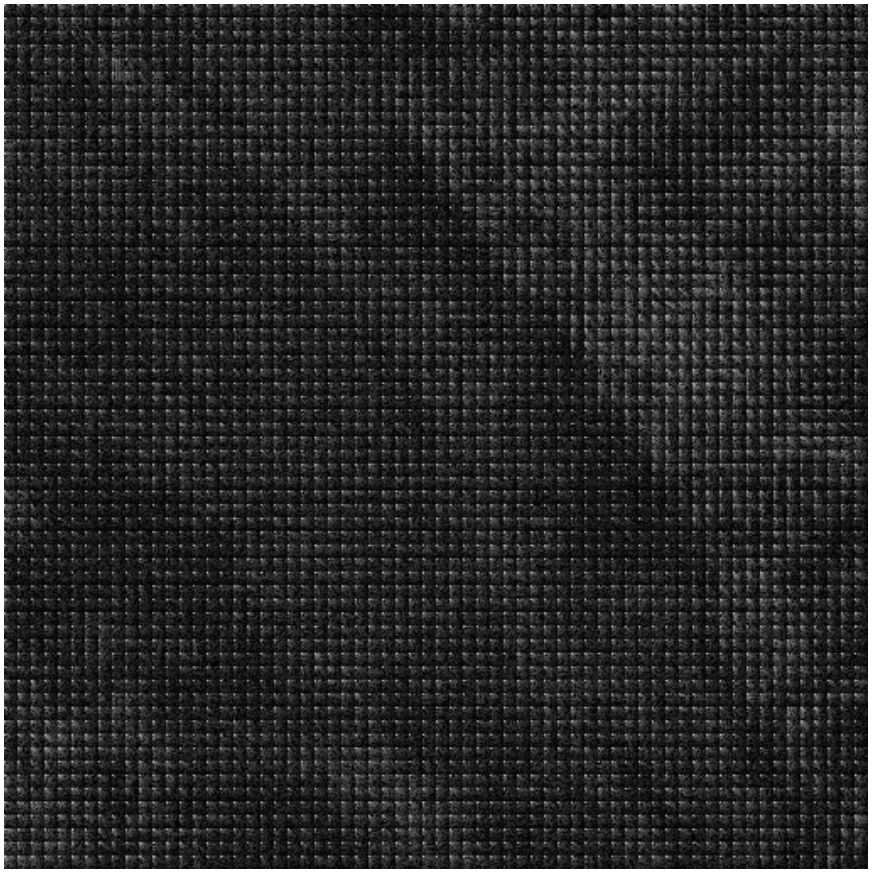


DWT

Transform Domain



DWT

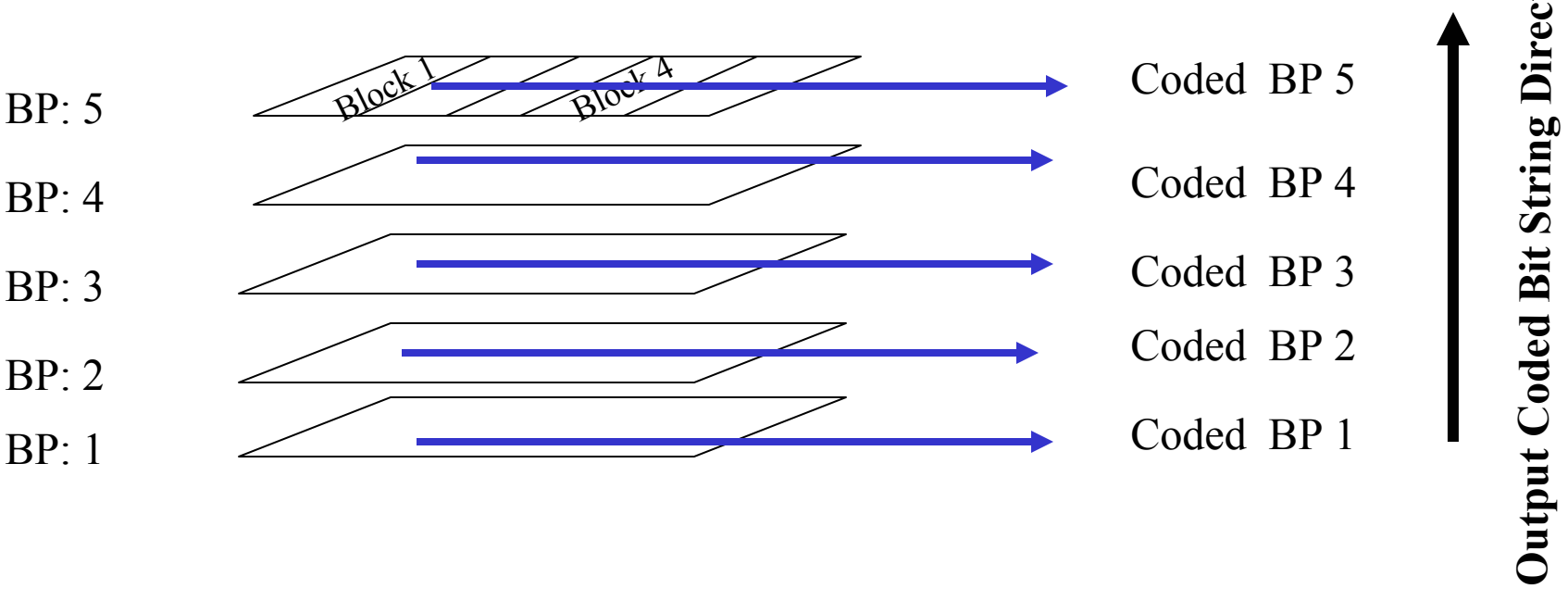


Lapped Transform

BIT PLANE ENCODER

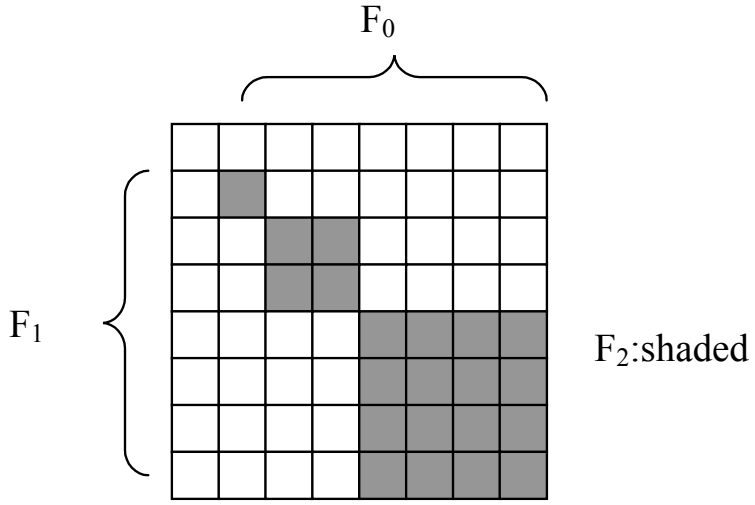
Multiple Bit Planes

Transformed Coefficients in Bit Planes:



BIT PLANE ENCODER

Blocks on Bit Plane



Scanning on each bit plane

Direction: F_0 => F_1 => F_2

Coding: 3 main levels/block

Output: embedded bit string

=> progressive decoding

* No look up table
* > 20 Msamples/sec
* Radiation Tolerant implementation
* Progressive decoding for quick-look

CCSDS WG SELECTION

CCSDS Image Data Compression Working Group (Sub-Panel 1C) has been trying to select an algorithm as recommendation for space implementation.

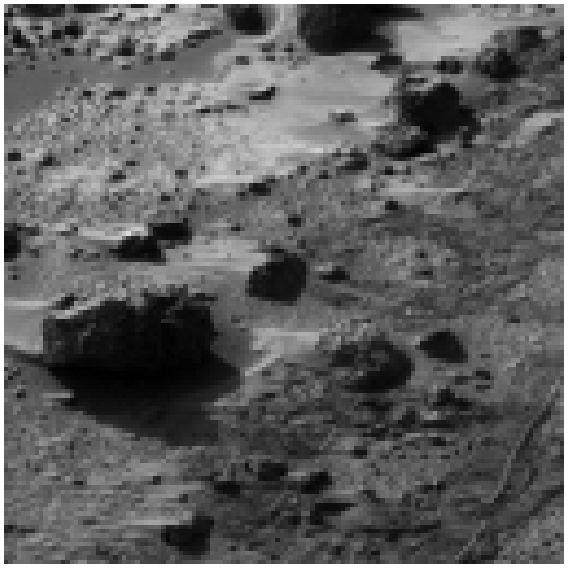
After nearly 5 years of work on evaluating performance, implementation issues, impact on science it finally made a decision (April, 03) to adopt:

- Discrete Wavelet Transform: 9/7 floating and 9/7 (or 5/3) integer
- Bit Plane Encoder

With integer wavelet, the scheme will provide from high compression ratio, to visually lossless and to mathematically lossless performance.

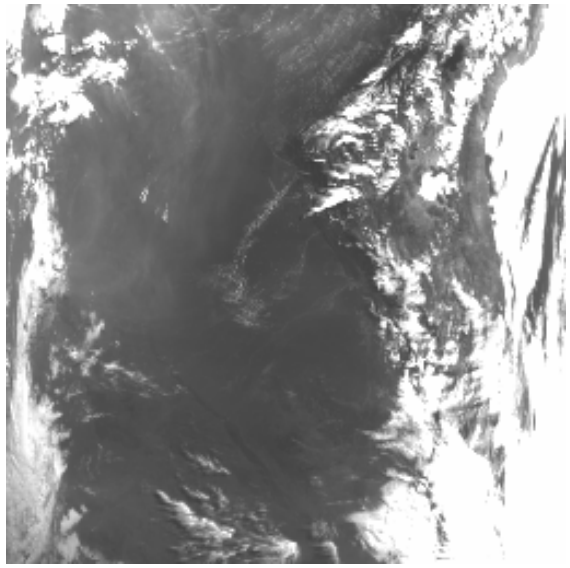
Agency review on Red Book will commence after October 03, with Blue Book/Green Book and S/W projected July 2004.

TEST IMAGES

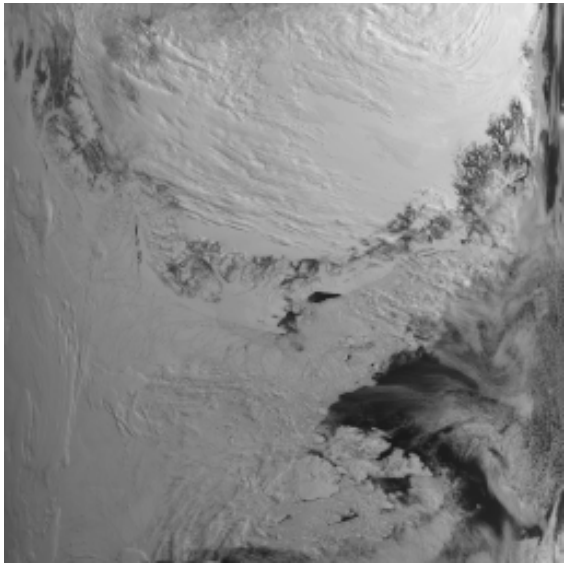


Mars

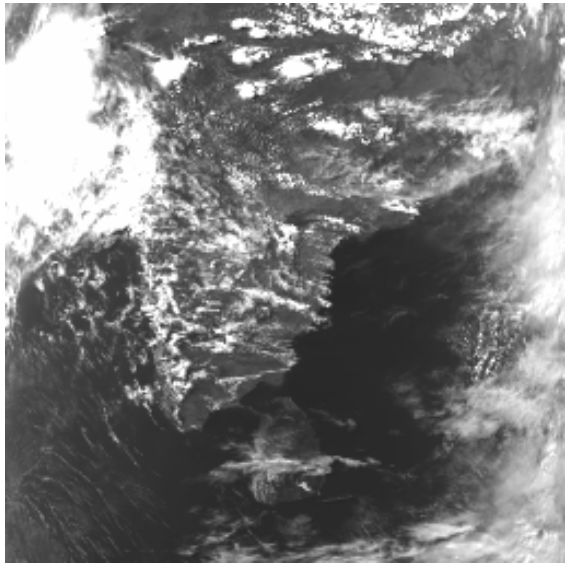
SPOT



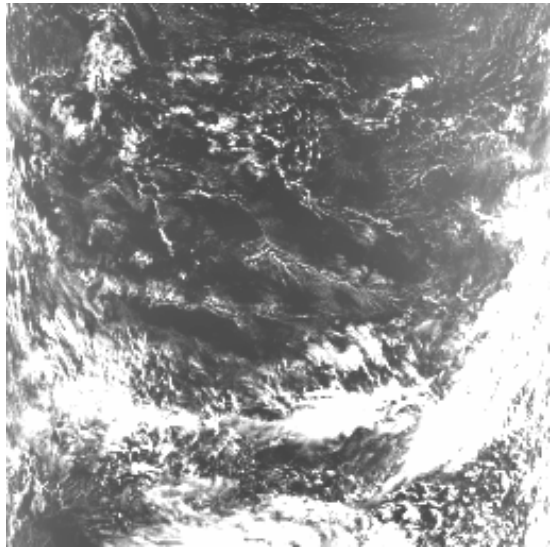
FOREST(AVHR)



ICE(AVHR)

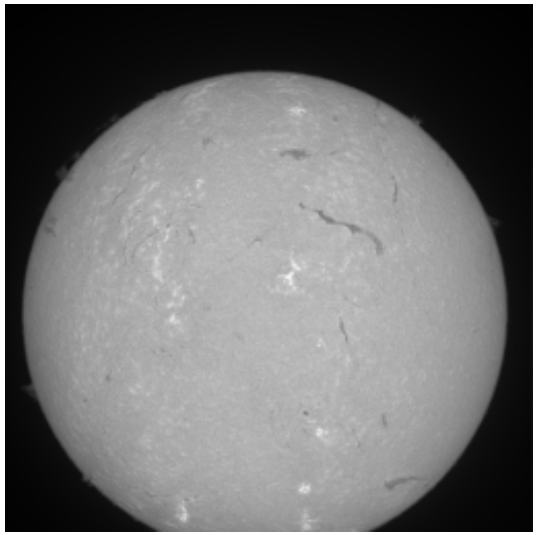


INDIA(AVHR)

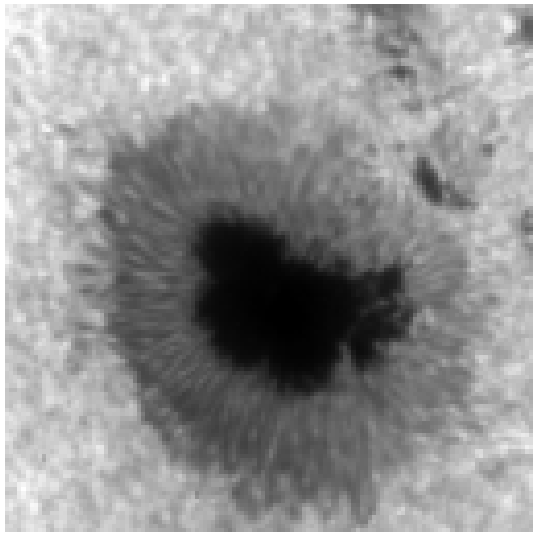


OCEAN(AVHR)

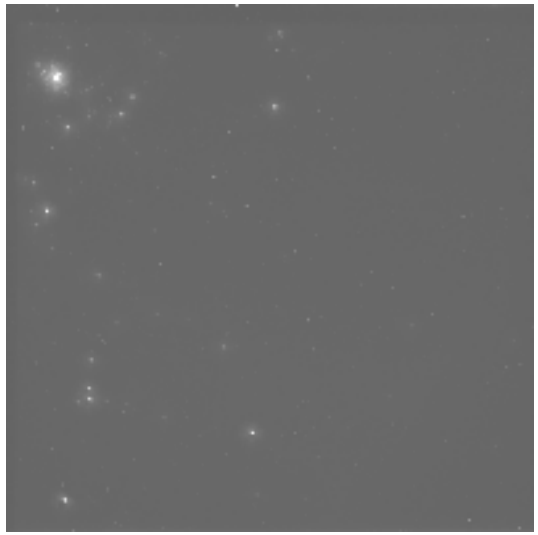
TEST IMAGES



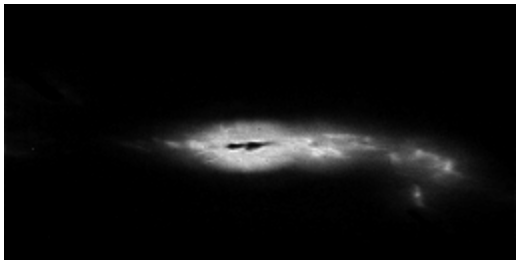
SOLAR



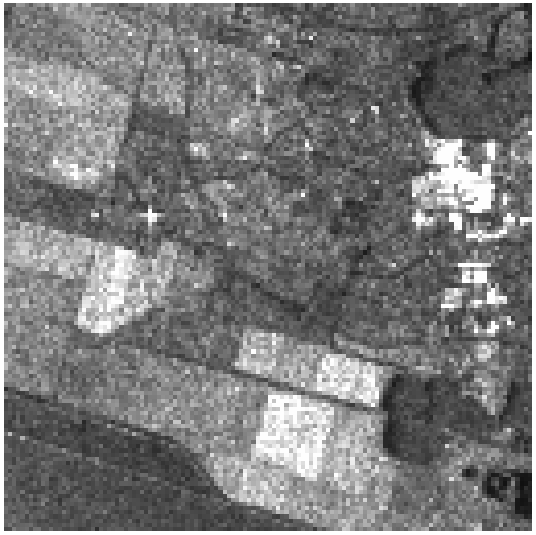
SUNSPOT



WFPC



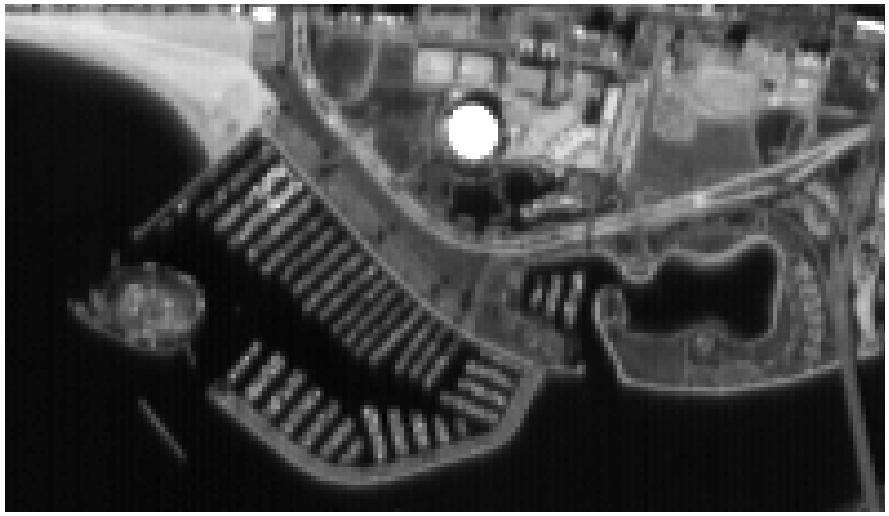
FOC



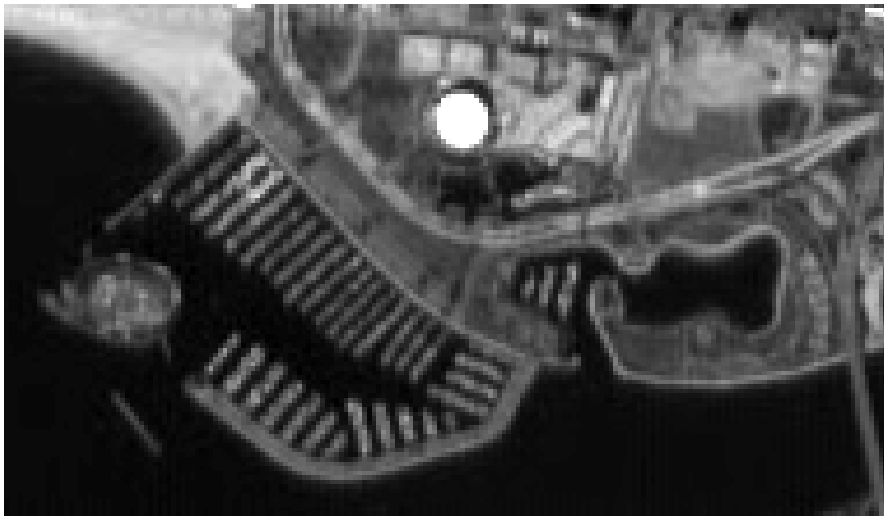
SAR

PERFORMANCE

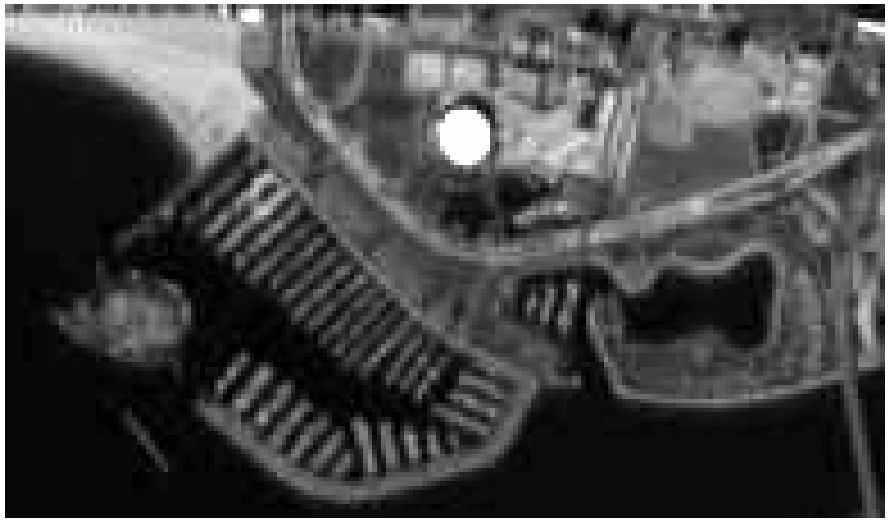
Visual Evaluation Performed at 1.0 bpp



Original



2DMLT

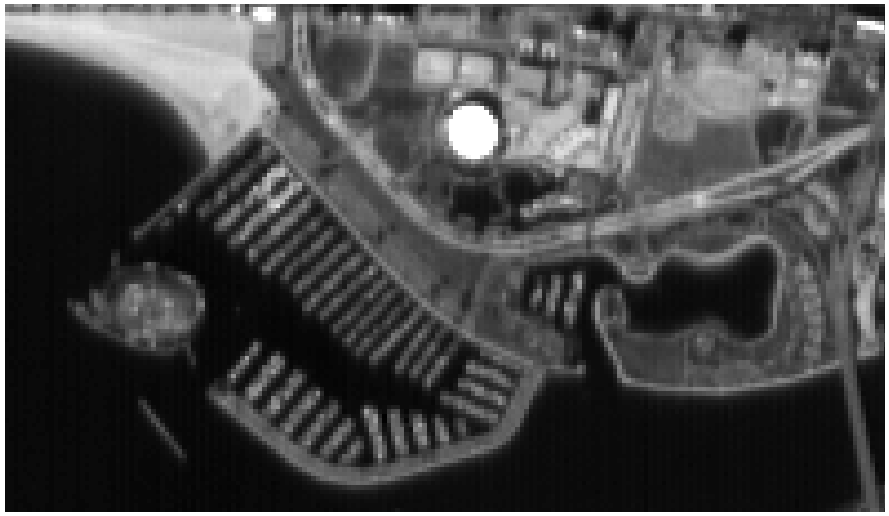


JPEG

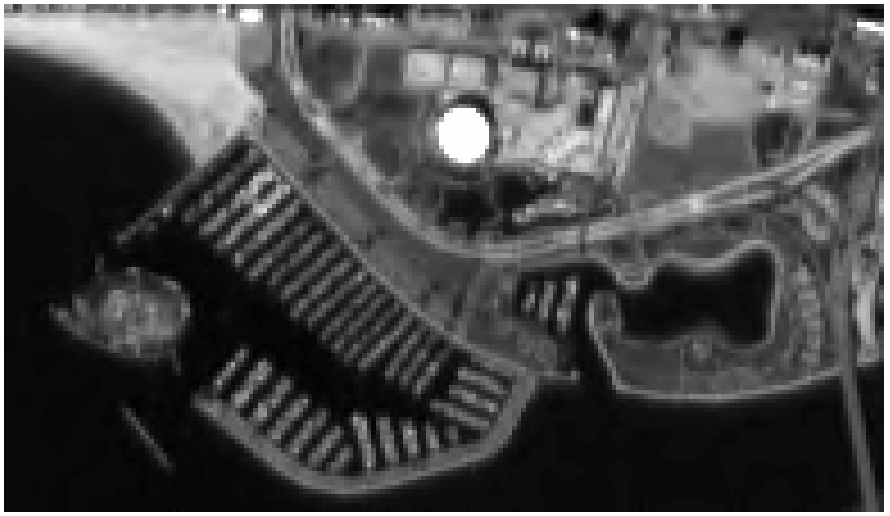
JPEG2000

PERFORMANCE

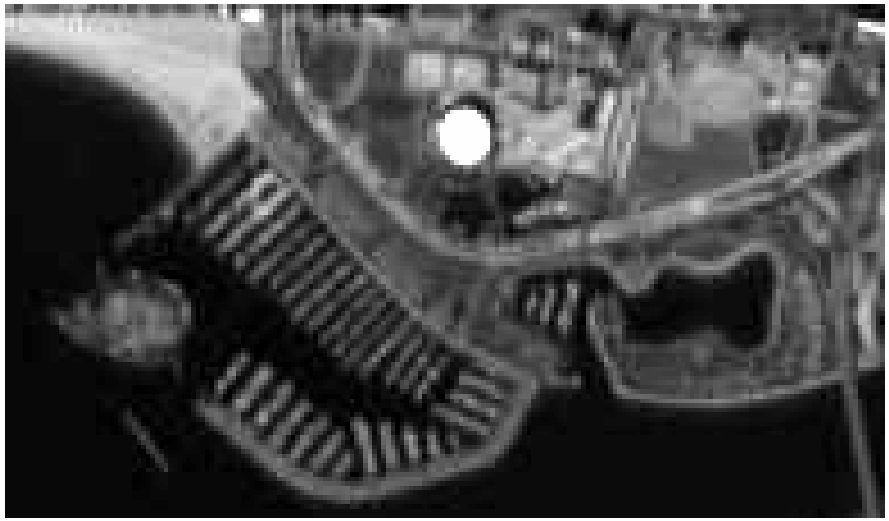
Visual Evaluation Performed at 1.0 bpp



Original



CCSDS

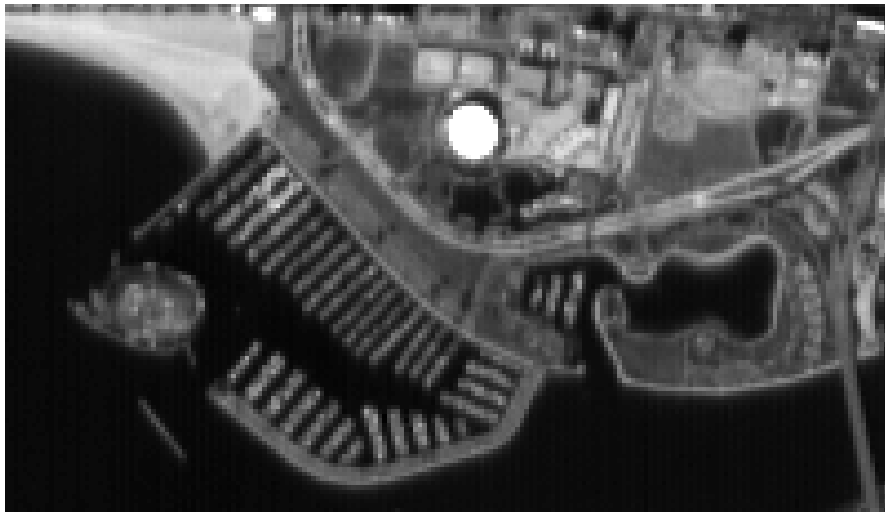


JPEG

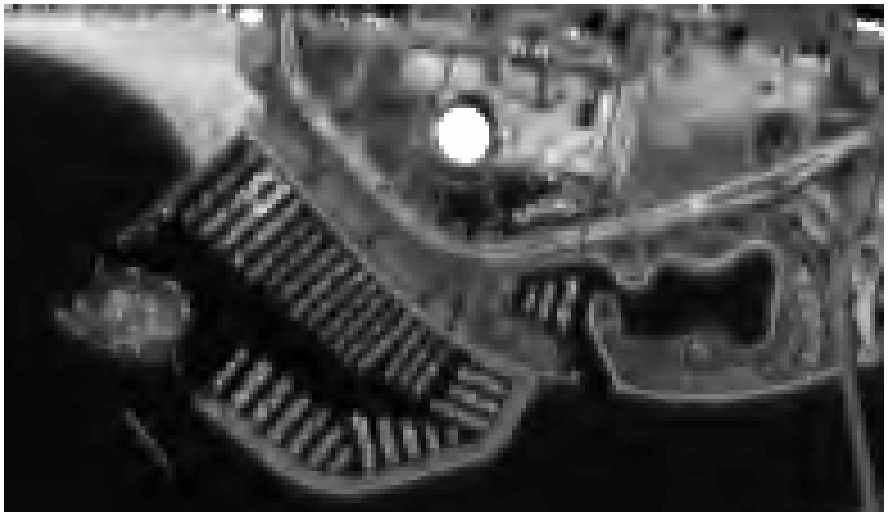
JPEG2000

PERFORMANCE

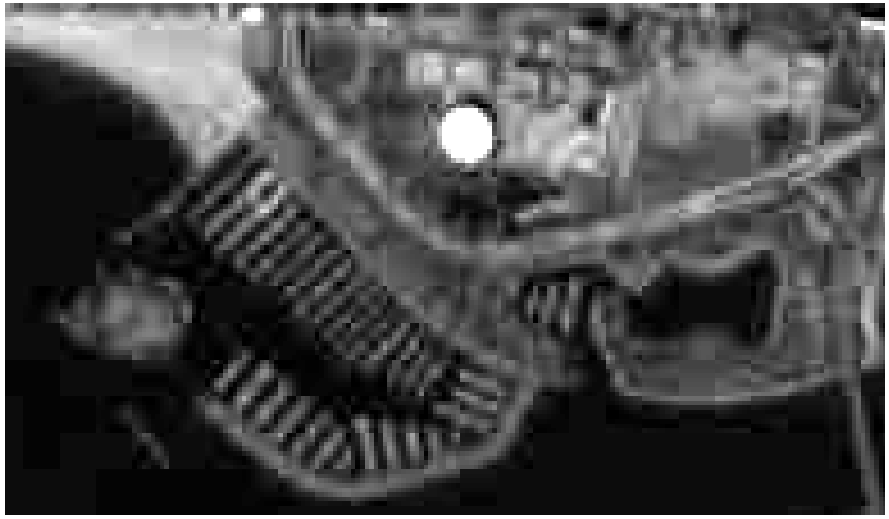
Visual Evaluation Performed at 0.5 bpp



Original



CCSDS



JPEG

JPEG2000

PERFORMANCE

Visual Evaluation Performed at 1.0 bpp

Original

CCSDS

JPEG

JPEG2000

PERFORMANCE

Visual Evaluation Performed at 0.5 bpp

Original

CCSDS

JPEG

JPEG2000

TECHNOLOGY STATUS

- **Earlier version on Lewis for Hyper-Spectral-Imager (data cube compression, '97)**
- **DCT/EDCT RT chip fabricated (**upto 16-bit input**), tested at 35 Msamples/sec**
- **2D DWT chip planned 2004-5 design/fabrication**
- **Bit Plane Encoder chip under design ==> 2004 fabrication**
- **System power estimated at 0.36 watt/Mpixel/sec**
- **Software simulation performed on various types of images**
- **Performance impact on science product under study**
  - **--** sea surface temperature --on NOAA-14 data,
    mean error < 0.01k from 0.25 - 2 bpp, 5/00
  - -- Retrieval for sounder (HES) data (GOES-R)